

## 1.7

# **ANALOG SITE FOR CHARACTERIZATION OF CONTAMINANT TRANSPORT THROUGH FRACTURED ROCK**

### **TECHNOLOGY NEED**

Many contaminated sites are located in fractured rock. For example, the ORNL has significant contamination in fractured shale. INEL and the Hanford Sites have problems in fractured basalt. The characterization of these sites in order to predict the transport of contaminants can be problematic. The location of fractures is often a mystery, and their effect on flow can be dramatic. The fractures themselves may be leached by reactive waste material. Containment of the waste may require the sealing of fractures. Thus, the three key issues that influence remediation of these sites are:

- Finding the fractures that control fluid flow and transport
- Analyzing fluid flow and transport in the fracture system
- Controlling of contaminant transport in the fracture system

### **TECHNOLOGY DESCRIPTION**

This project is designed to identify reliable tools and methodologies for characterizing the fracture systems that control flow and transport in specific geologic settings. Characterization tools will be used to predict the outcome of flow and transport experiments in fractured rock in order to assess the utility of these tools for characterizing important hydrologic features in similar contaminated sites.

At an analog site in the Snake River Basalts, two series of measurements are being performed. The first series is designed to characterize the hydrology of the site. The second set is a flow and transport experiment designed to test the predictive capability of the characterization methodology.

The characterization phase began with a geologic investigation designed to identify the style of fracturing and the likely fracture patterns as shown in Figure 1.7-1. Then geophysical investigations were performed to locate the features of the fracture system that control fluid flow. Radar reflection and tomography, and hydraulic interference testing was used as shown in Figure 1.7-2. The interpretation(s) of these measurements will consist of one or more estimates of the location of important hydrologic fractures, and how they are connected. These features will then become part of the conceptual model for infiltration.

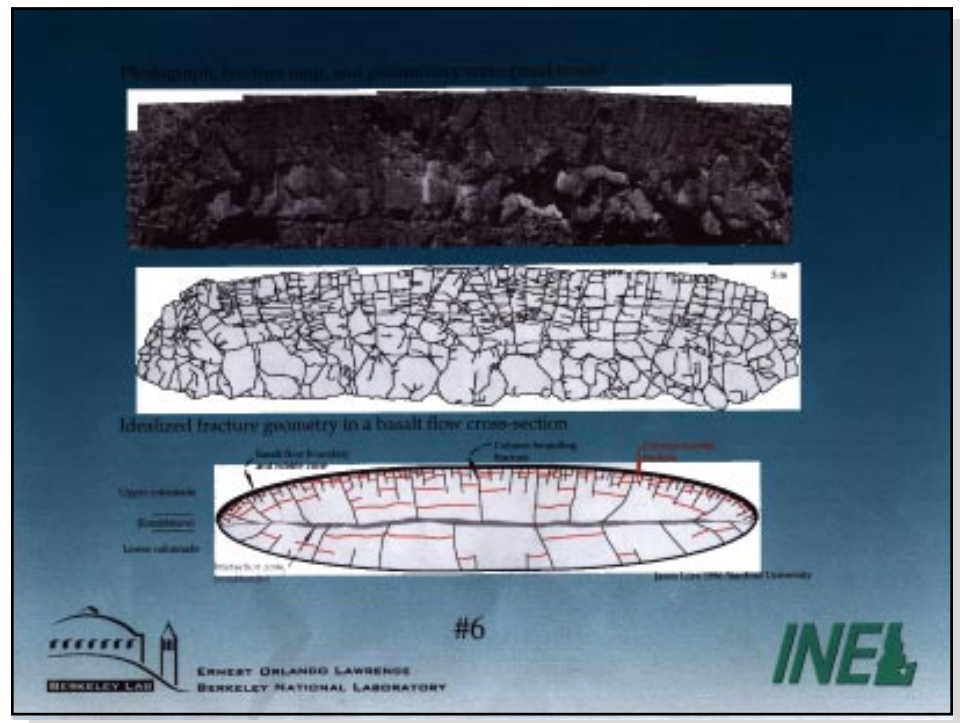


Figure 1.7-1 Idealized fracture geometry in a basalt flow cross-section

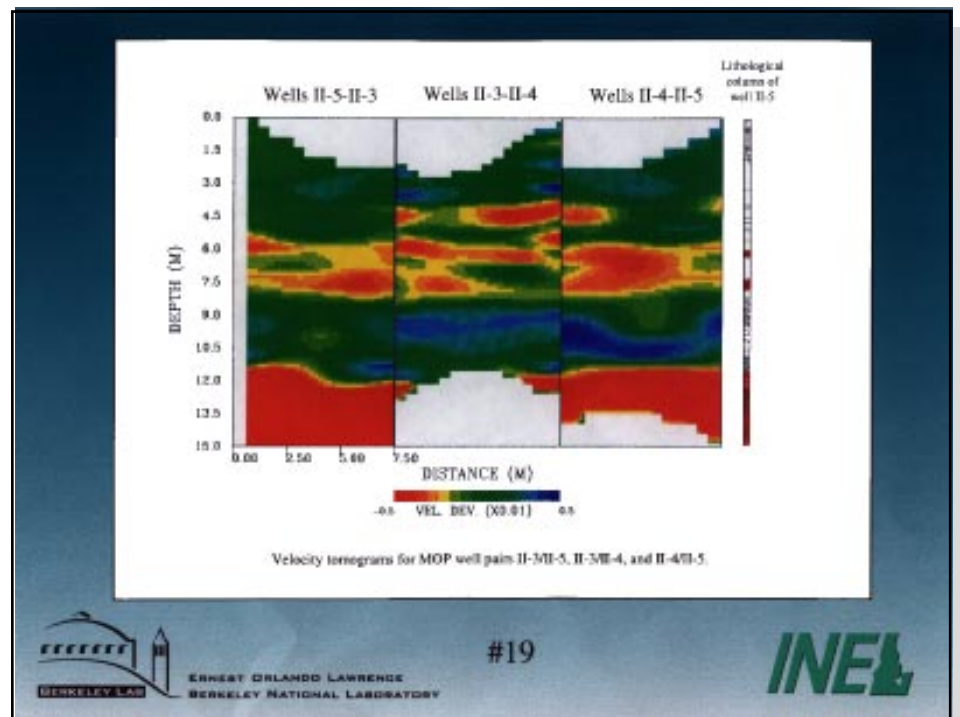
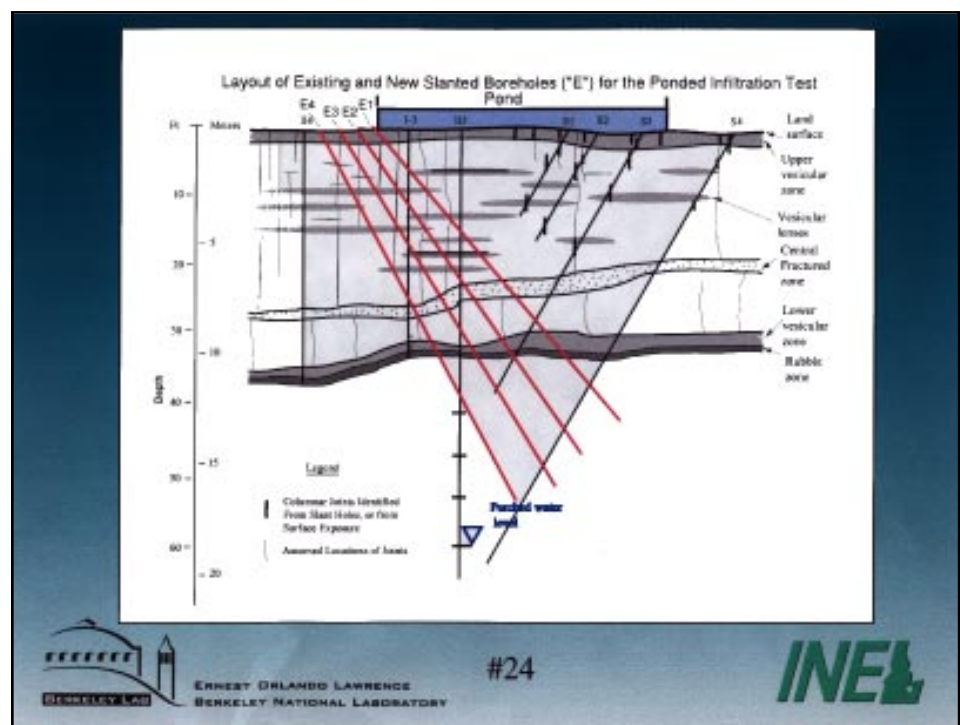


Figure 1.7-2 Velocity tomograms for MOP well pairs II-3/II-5, II-3/II-4, and II-4/II-5

An infiltration test is planned for the summer of 1996. Test design and site preparation are underway as shown in Figure 1.7-3. The test will be conducted over an area less than 10m by 10m. Parallel slanted boreholes have been drilled at the site and will be instrumented to detect fluid flow. Instrument placement will be determined based on the conceptual model developed with FY95 data. Two pairs of slanted holes will be used for geophysical monitoring with radar tomography, which will be done before and during the infiltration test. The idea is to image the flow through flow-induced changes in geophysical properties. Comparison of the flow experiments with the flow patterns predicted in the first phase will provide a format for identifying those methods, or combinations of methods, that successfully identify the fractures that control flow.



**Figure 1.7-3** Layout of existing and new slanted boreholes ("E") for the ponded infiltration test

## BENEFITS

The results of this project fall in two categories. First, the project is being conducted in a rock mass that is analogous to a significantly contaminated rock mass. Therefore, the tools developed and checked at this site will be reliable for use in the real contaminated site. The radar method tried at Box Canyon is applicable to characterization of the OCVZ (Organic Contaminated Vadose Zone) site at INEL. Many of the vadose zone instruments such as the deep tensiometers are of use to the ICPP or the RWMC (Radioactive Waste Management Complex). More importantly, the methodology for characterizing fractured materials at the INEL contaminated sites can be extended to other sites, making it possible to move on to new geologic settings much more efficiently.



## **COLLABORATION/TECHNOLOGY TRANSFER**

Parsons Environmental participates in the project as a contractor. Stanford University provides the geologic investigation of fracture systematics. EMI, Inc., a small business, is contracted for geophysical surveys. Traditional geophysical service companies and other geotechnical firms can learn from this project, either by direct participation or through the results of the project. Interest in the technology developed by the project could be quite large, as there are many contaminated sites in fractured rock. In FY95 we collaborated with a DoD database design project.



## **ACCOMPLISHMENTS**

A study site has been identified in the Snake River Basalts at the Box Canyon site, and a close collaboration between Berkeley Lab and INEL has been established. A successful field season in FY95 included hot air injection tests, air interference tests, radar tomography and geologic investigations. The hot air injection into boreholes was designed to find connections between the fractures below the ground and the surface. No temperature changes were detected at the surface, but connections were determined between boreholes. Then air interference tests were conducted to determine the connections between the fractures. Radar tomography was tested and produced high resolution images, which delineated the major features of the site quite well. Vadose zone instrumentation designed to work in fracture systems was designed and tested.

In addition, four other tasks were completed. A study was conducted to determine the feasibility of using a combination of isotope ratios and hydraulic head to determine the location of fast pathways in the Snake River Aquifer. This study had favorable results and led to a successful new proposal to do this work. A second study used hydrologic inverse methods designed specifically for fractured rock to analyze the data from the Large Scale Aquifer Stress Test. The results revealed the salient features of the heterogeneity in the fractured basalts, and indicated the utility of using this type of analysis in the basalt aquifer. A third study compared the use of the CSAMT (Controlled Source Audiofrequency Magnetotelluric) method with that of resistivity at the site of the Large Scale Infiltration Test (LSIT). The CSAMT method is a version of magnetotellurics which has advantages over simple resistivity. The two methods produced similar anomalies. Finally, we developed a database management system (AVS) that was directly linked to the application visualization system for LSIT data, allowing the user to select and immediately visualize data in one system.

## TTP INFORMATION

Analog Site for Characterization of Contaminant Transport Through Fractured Rock technology development activities are funded under the following Technical Task Plan (TTP):

TTP No. SF141001 "Analog Site for Characterization of Contaminant Transport Through Fractured Rock"

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